CHAPTER 5

OXYGEN SUPPORT EQUIPMENT

Terminal Objective: Upon completion of this chapter, you will be able to describe safety precautions and procedures for handling liquid or gaseous oxygen and its support equipment, describe liquid oxygen storage procedures, and recognize contamination control procedures.

Oxygen systems on naval aircraft require several types of support equipment to ensure their safe and satisfactory operation. AMEs are concerned with support equipment that is used for storage and servicing of oxygen. In this chapter, storage tanks and servicing equipment are discussed.

As an AME it is your responsibility to know and understand the safety precautions that are involved when working with or handling liquid or gaseous oxygen and its support equipment.

This information should not stop with just the personnel of your rate, but it should be stressed to all aviation maintenance personnel, so they won't mishandle or mistreat AME support equipment. Examples include playing with valves of service trailers, standing or sitting on trailers, hauling tools and equipment on them, spilling oils and other fluids on them, etc. Their awareness will reduce the possibility of creating hazardous conditions that could cause serious injury to themselves or others.

Safety precautions applicable to this chapter are covered throughout the text. Oxygen safety precautions can also be found in NAVAIR 06-30-501, *Technical Manual of Oxygen/Nitrogen Cryogenic Systems.*

LIQUID OXYGEN STORAGE

Learning Objective: Describe safety precautions and handling procedures for liquid oxygen storage tanks, transfer lines, and valves.

Liquid oxygen (LOX) is centrally stored on naval air stations for issue to users. Few Navy requirements involve containers over 2,000 gallons. The design features and practices described in this chapter apply generally to all sizes of containers. The main emphasis is on tanks of 2,000 gallons and under. Figure 5-1 shows a 2,000-gallon-capacity storage tank.

TANKS

The tank is used for the storage of LOX at low pressure, with low evaporation loss, and for transferring of LOX to smaller containers, as required.

All LOX storage tanks are basically similar, regardless of their size or configuration, whether they are skid mounted, trailer mounted, or permanently installed. They all consist of an

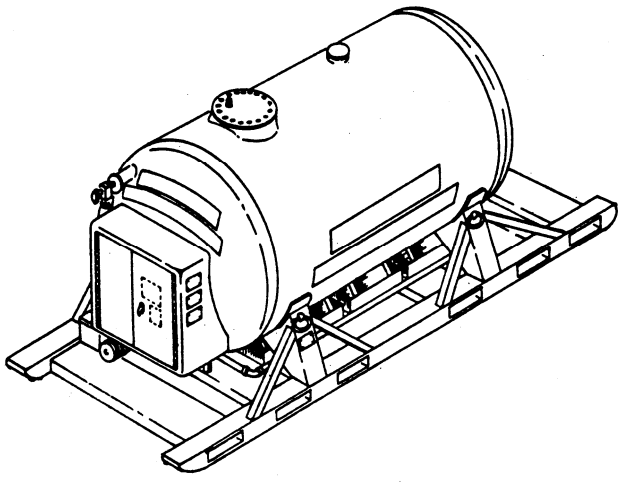


Figure 5-1.—2,000-gallon-capacity liquid oxygen storage tank.

inner and outer container separated by a circular insulated space (the annulus) that is packed with a powder-type insulating material and highly vacuum pressured to minimize heat transfer and evaporation losses.

TRANSFER LINES

Aside from certain large fixed facility piping, most LOX systems are made up of transfer lines—often segmented (in sections) for ease of demountability (reconnecting) so one transfer system can service several pieces of equipment. Generally, what is true for insulation of tanks is applicable to other similar equipment with the exception of transfer lines. Transfer lines are cooled and warmed many times during the course of a day. The liquid oxygen waste due to cooldown losses can be significant. A high vacuum insulated transfer line generally is best for quick, frequent transfers since no insulated cooldown mass is involved. To help reduce LOX waste due to cooldown of transfer lines, several wraps of multilayer insulation adds very little mass to the system, decreases the thermal radiation, and requires less vacuum (if any) in the insulation annulus.

Transfer lines are most commonly constructed of bronze, stainless steel, or aluminum. In the case of vacuum-jacketed lines, annular spaces are necessary to prevent the inner liquid-bearing lines from touching the outer jacket wall. Low thermal conductivity materials are used for this purpose, and schemes are incorporated into the spacer design to provide only a small area contact wherever possible, since the heat influx must be kept low.

Although rigid lines often are used in stationary facility piping installations and for some remountable applications, the predominant type for use in the field is corrugated flexible metal transfer hose (fig. 5-2).

Flexible metal hose is somewhat more vulnerable to abuse than its rigid counterpart; therefore, it usually has a braided metallic covering or tough plastic sheath over the external corrugations. The high working pressure capability of the inner line requires the application of a strengthening braid over it as well. Even though such protection provides a degree of reinforcement to the hose, it should not be subjected to overpressurization in service since a bellowslike action still may be possible if the covering is not securely fastened at the end connections. High pressure expands the hose axially, causing it to grow by lengthening the distance between each corrugation, which makes the line less flexible.

A vital consideration in the construction of all transfer lines is the matter of joints between line segments. Assuming that the transfer lines are vacuum-jacketed to the general region of the joint, the concern with the joint and the closure of the vacuum-jacket in close proximity to the joint is important. The transfer line connector/coupling (bayonet coupling) in figure 5-3 is one of the better designs available today, and the most expensive.

To safely and efficiently use transfer lines, several things must be remembered. NEVER trap liquid in a line between closed valves unless you are absolutely certain that some type of relief device is functionally associated with the inner

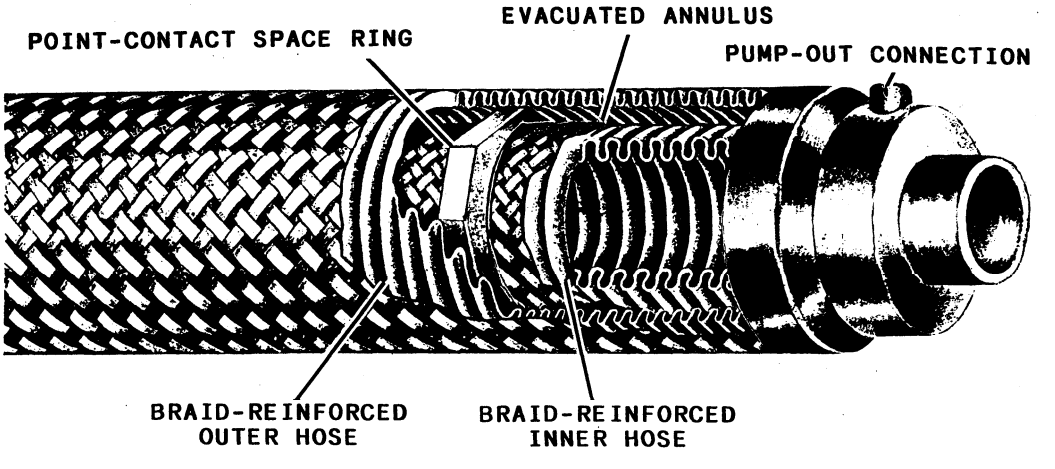


Figure 5-2.—Flexible metal transfer hose.

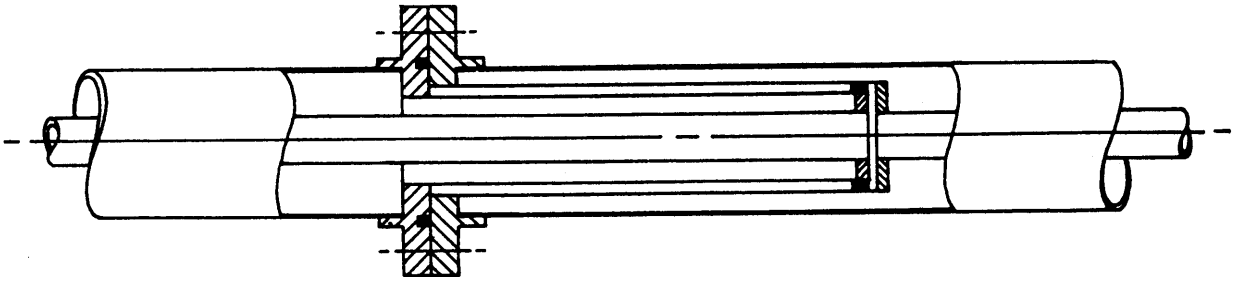


Figure 5-3.—Transfer line connector/coupling.

line. The reason is that as the LOX vaporizes, the vapors will warm, and excessive pressures may develop that can burst the conduit walls.

For transfer efficiency, vacuum-jacketed lines with well-designed, low-heat input couplings are best for most uses. Unthinking use of two or three transfer sections coupled together where one could do the job wastes liquid and time. Several times as much line material has to be cooled down, and several times more heat transferring line surface area is contacted by the LOX. Additional heat influx means additional LOX vaporization; therefore, more liquid is needed to satisfy a given transfer demand.

VALVES

Although valves might appear to be of minor concern in a system, low-temperature valves often cause more trouble than any other element of the system. In addition to the general requirements for any valve, LOX valves must be able to function properly at extremely low temperatures without causing excessive boil-off losses to the liquid flowing through them. Insulation is the best method to meet these thermal requirements. Various materials have been used for insulation, but the best method is to vacuum insulate the valve. The valve illustrated in figure 5-4 is typical of this type. The method of operation will vary by manufacturer.

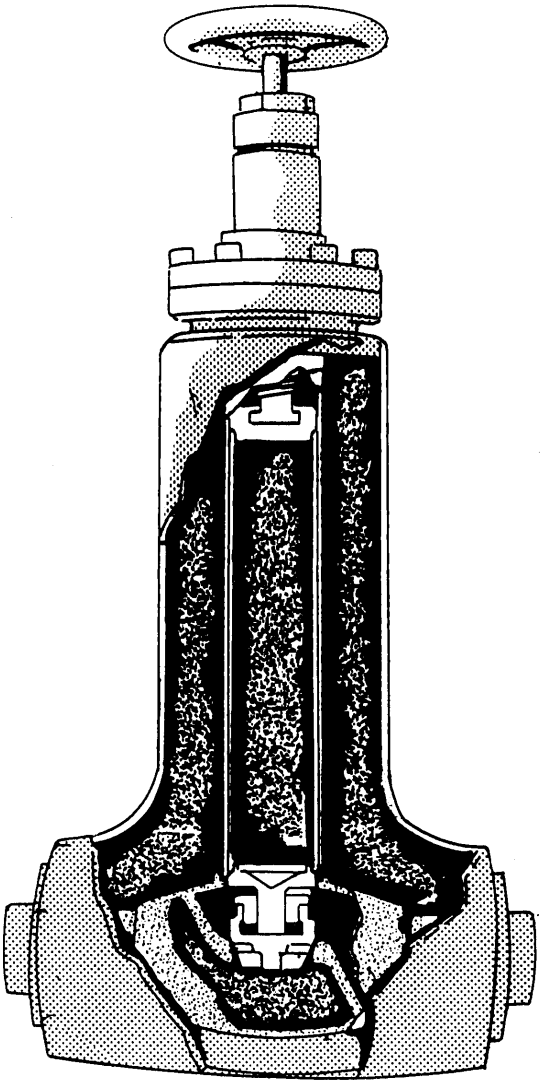


Figure 5-4.—Vacuum-insulated cryogenic valve.

OXYGEN SERVICING EQUIPMENT

Learning Objective: Describe oxygen *servicing equipment to include safety precautions, servicing trailers, and system servicing.*

Oxygen servicing equipment for both liquid and gaseous oxygen systems are discussed in this

section. Since AMEs operate this equipment, they must be familiar with purging and sampling procedures as well as operation of the equipment while servicing aircraft oxygen systems.

SAFETY PRECAUTIONS

The following safety precautions must be observed when handling LOX.

1. Never allow LOX to contact your skin. The extremely low temperature of the liquid quickly freezes skin, and severe frost bite results. If your skin is splashed with LOX, immediately flush the area thoroughly with water, and then obtain first aid.

2. Always store LOX with the vent valve open. Relief valves on the tank protect the tank in case of malfunction, and are not to be used as pressure regulators.

3. Never confine LOX in piping or a container without adequate safety devices. When the liquid expands to a gas, the pressure buildup will rupture most piping, tubing or containers.

4. Comply with all safety directives. Fifty feet away is the safe distance to permit smoking, open flames, or sparks in a LOX handling area. Assure that painting and markings on the LOX tank are maintained as required. Oxygen gas does not burn, but it vigorously supports combustion of any material that does burn.

5. Keep LOX away from absorbent materials, loose clothing, or rags. These materials can trap oxygen gas and later be ignited by a spark, cigarette, or match.

6. When LOX equipment is in use, keep it in a well ventilated area away from all gasoline, kerosene, oil, grease, and other hydrocarbons. These substances are not compatible with LOX. Spontaneous ignition may result from contact with these substances.

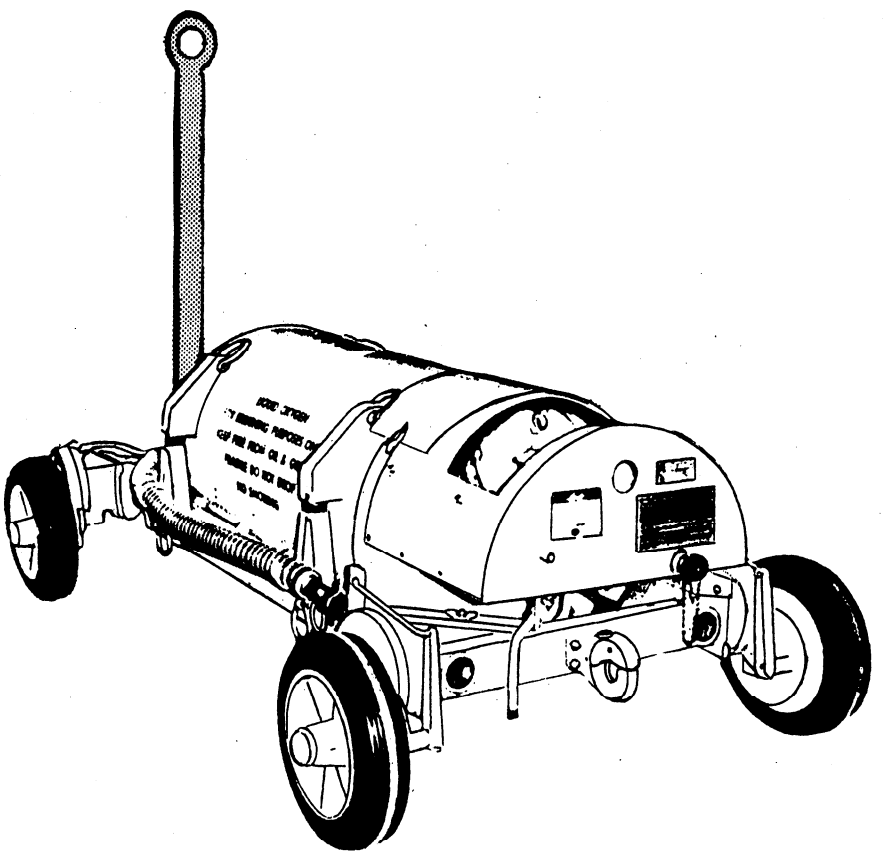


Figure 5-5.—Liquid oxygen servicing trailer, type 7.

LOX SERVICING TRAILERS

The primary purpose of portable transfer equipment is to provide a means of servicing oxygen systems installed in aircraft.

There are currently two types of LOX servicing trailers in use by the Navy—the standard type 7 trailer, which vents gaseous and liquid oxygen overboard through the vent fitting of the LOX converter as it is being filled (fig. 5-5), and the TMU-70/M low loss, closed loop trailer, which recaptures these vented losses (fig. 5-6). The TMU-70/M trailer is manufactured by Cryogenic Engineering Company and has been selected for coverage in this training manual.

TMU-70\M, Low Loss, Closed Loop Liquid Oxygen Servicing Trailer

During LOX servicing of aircraft converters, a lot of oxygen is lost because of the way the transfer is carried out. In addition to the economic loss, a safety hazard is created when LOX or oxygen vapors are released into the atmosphere near operating equipment and personnel. The low loss, closed loop system was designed to significantly reduce these losses and eliminate the safety hazards associated with venting oxygen in critical areas.

DESCRIPTION.— The TMU 70/M is a completely self-contained unit with three major components: a 50-gallon Dewar tank, a 15-liter Dewar transfer tank, and a low loss, closed loop (LLCL) system of transfer lines. Separate liquid level and pressure gauges, as well as pressure relief devices, are provided for each tank. These components are permanently mounted on a portable three-wheel trailer, which is equipped with a manually operated parking brake and retractable caster wheel.

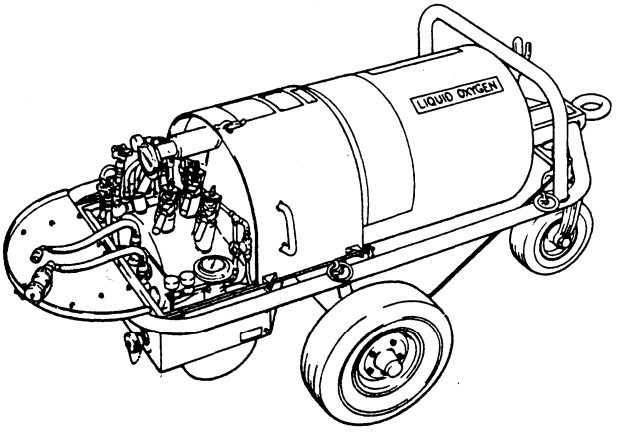


Figure 5-6.—TMU-70/M low loss, closed loop, liquid oxygen servicing trailer.

The primary purpose of the TMU 70/M is to service aircraft LOX converters. The LLCL system is designed to recycle oxygen vapor caused by heat losses during transfer to the aircraft converter. The oxygen vapors vented from the transfer tank and aircraft converter are returned to the storage tank for cooldown and retention.

Storage Tank.— The storage tank is a 50-gallon (U. S.) capacity, double-walled Dewar. The space between the double walls of the storage tank and the transfer tank is evacuated down to 5 microns or lower and contains a multilayer, high-vacuum insulation to minimize heat gain and boil-off of the LOX.

Transfer Tank.— The 15-liter-capacity transfer tank is a double-walled, vacuum-insulated Dewar, permanently attached to the storage tank. It is self-contained and gravity filled from the storage tank. The transfer tank is equipped with a pressure buildup coil, relief valve, rupture disc, and controls. The primary function of the transfer tank is to hold small volumes of LOX and to utilize cold gas pressure from the pressure buildup unit to transfer LOX to the aircraft converter.

Transfer Lines and Piping System.— These lines carry the LOX from the storage tank to the transfer tank, and then to the aircraft converter. They also carry the vented oxygen gas from the aircraft's converter to the storage tank.

The closed loop system of the transfer lines contains the vented oxygen gas during filling operations. The interconnected liquid and return gas lines are vacuum-jacketed wherever practical and are of minimum length to reduce cooldown and heat leak losses.

The piping system consists of a fill line for storage tank filling, a vent system for overboard venting of excess liquid or gas, and a pressure relief valve system connected to the vent system.

Controls And Indicators.— The controls and indicators of the TMU-70/M are illustrated and

identified in figure 5-7. The storage tank pressure gauge (1) indicates the pressure in the inner tank. The storage tank liquid level gauge (2) indicates the level of liquid in the inner tank when the tank is on level ground. The dial is magnetically and mechanically coupled to a float sensor inside the storage tank and is calibrated in gallons. The transfer tank pressure gauge (8) indicates the pressure in the transfer tank. This pressure must be more than that in the storage tank for the liquid to transfer, since the converter is vented into the storage tank during converter filling. The transfer tank liquid level gauge (7), which reads in percent full, is the same type as the storage tank liquid level gauge that reads in gallons. The converter full indicator gauge (9) (marked LIQUID—GAS on the gauge), is a vapor pressure thermometer that monitors the converter vent line temperature. During transfer of liquid to a converter, it indicates "GAS" temperature in the converter vent line. When the converter is full, the vent line is filled with LOX. The converter vent line temperature drops and the gauge indicator moves to the "LIQUID" position that indicates a full converter.

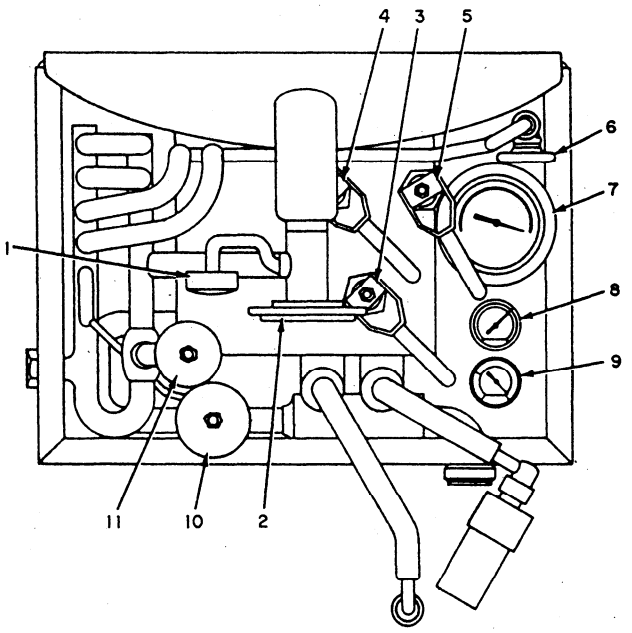
With the exception of the converter full indicator gauge and the transfer tank liquid level gauge, all gauges have a green band to indicate safe operating pressures and a red band to indicate unsafe pressures.

In addition to the indicators covered, there are several valves in the system. The converter vent line shutoff valve (3) controls the flow of oxygen gas vapors from the converter to the storage tank and prevents loss of storage tank gas when the converter is not being filled. The transfer tank vent line shutoff valve (4) controls the flow of oxygen gas vapors from the transfer tank to the vapor space of the storage tank.

The valve used to control the gravity flow of LOX to the transfer tank from the storage tank is the transfer tank fill line shutoff valve (5).

The transfer tank pressure buildup valve (6) controls the flow of LOX from the bottom of the transfer tank to the pressure buildup coil (PBU). The PBU coil is a heat exchanger that exposes the LOX to ambient temperatures, converting the LOX to gas. As this conversion takes place, the gas expands and the output gas from the PBU is fed back to the transfer tank vapor space, providing the pressure to discharge the LOX to the converter.

The fill drain line shutoff valve (10) is used during the storage tank filling operation. It permits the flow of LOX from a central supply tank to the storage tank. This valve is to be opened completely during the filling function and closed after the transfer has been completed.



1. Storage tank pressure gauge.
2. Storage tank liquid level gauge.
3. Converter vent line shutoff valve.
4. Transfer tank vent line shutoff valve.
5. Transfer tank fill line shutoff valve.
6. Transfer tank pressure buildup valve.
7. Transfer tank liquid level gauge.
8. Transfer tank pressure gauge.
9. Converter full indicator gauge.
10. Fill-drain line shutoff valve.
11. Storage tank vent line shutoff valve.

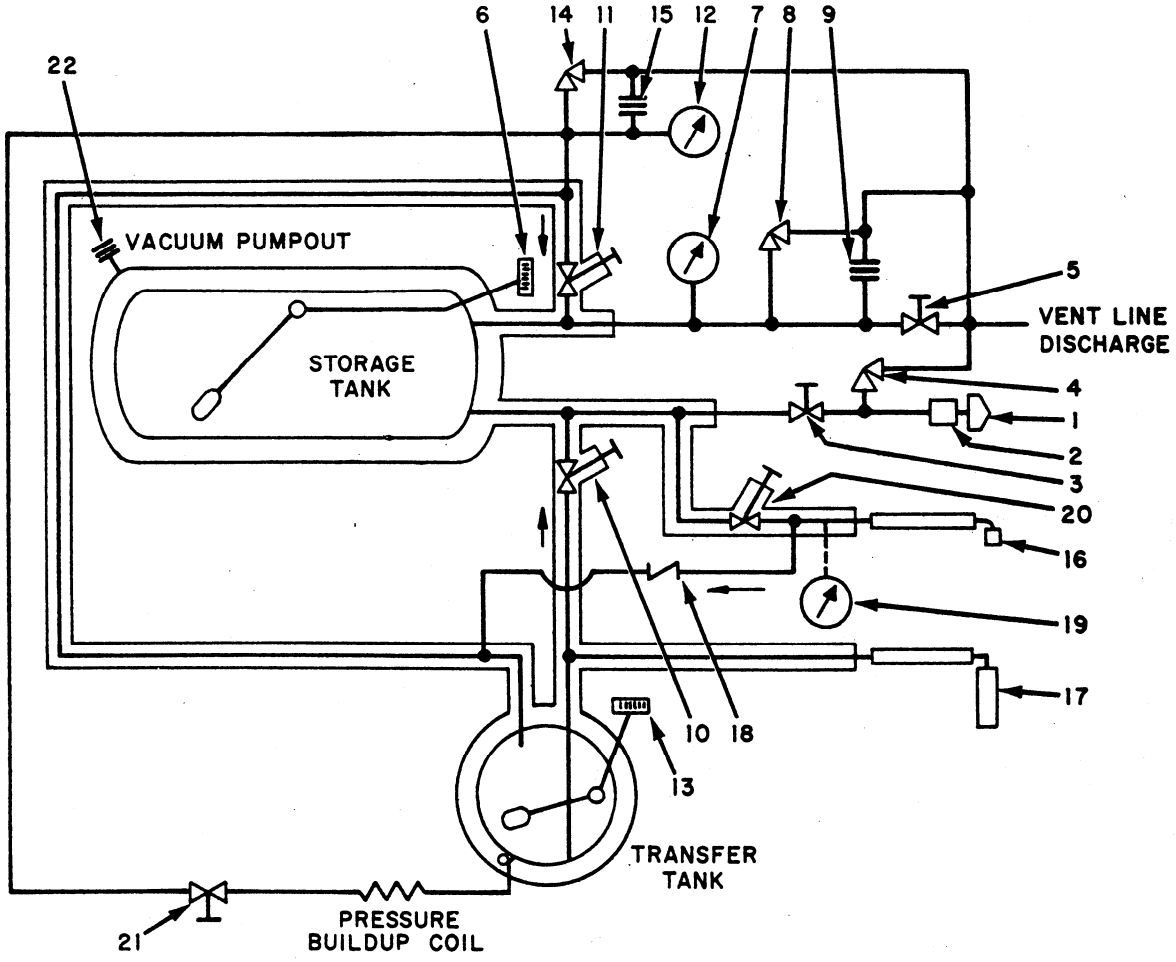
Figure 5-7.—TMU-70/M liquid oxygen servicing trailer controls and indicators.

CAUTION

The fill-drain line shutoff valve is not used to control flow. Restricting transfer flow may create a dangerous back pressure on the supply line used for filling. Control of transfer flow should be maintained with the service valve of the central supply tank.

The storage tank vent line shutoff valve (11) is used to control the release of gaseous vapors from the storage tank to the vent piping manifold. This valve is open during filling to vent all pressure from the storage tank. During idle storage, it is left open to vent all vapors generated by normal LOX boil-off. In flight line service, it is left closed to prevent oxygen vapor contact with flammable liquids or vapors, and to prevent unnecessary loss of LOX.

OPERATION.— The following procedures describe LOX flow in connection with filling the TMU 70/M storage tank and the servicing of an aircraft converter, using the trailer. The flow description is keyed to figure 5-8.



1. Fill-drain line coupling.
2. Fill-drain line filter.
3. Fill-drain line shutoff valve.
4. Fill-drain line relief valve.
5. Storage tank vent line shutoff valve.
6. Storage tank liquid level gauge.
7. Storage tank pressure gauge.
8. Storage tank inner shell relief valve.
9. Storage tank inner shell rupture disc.
10. Transfer tank fill line shutoff valve.
11. Transfer tank vent line shutoff valve.
12. Transfer tank pressure gauge.
13. Transfer tank liquid level gauge.
14. Transfer tank inner shell relief valve.
15. Transfer tank inner shell rupture disc.
16. Converter vent line connector.
17. Air force filler valve.
18. Converter vent line check valve.
19. Converter full indicator gauge.
20. Converter vent line shutoff valve.
21. Transfer tank pressure buildup valve.
22. Outer shell relief device.

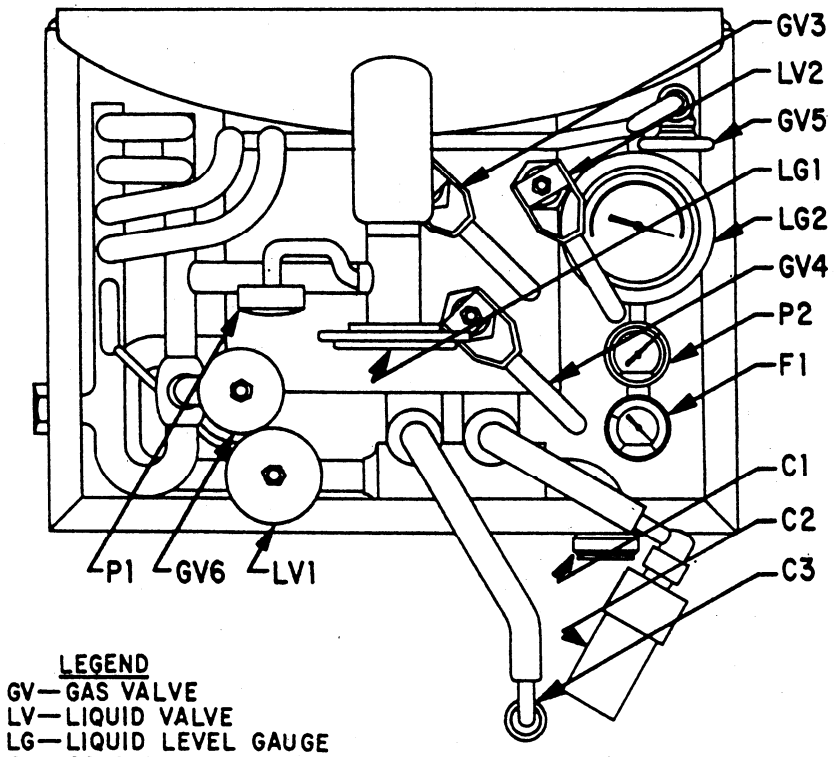
Figure 5-8.—TMU-70/M liquid oxygen servicing trailer storage tank schematic diagram.

Figure 5-9 shows the operating instructions from the plate attached to the trailer.

When the servicing trailer is received from the factory or from an overhaul activity, it is normally ready to be filled with LOX and pressurized for immediate use. The annular space is evacuated to the point desirable for a warm and empty tank. Prior to filling or pressurizing the tank, perform the inspection procedures indicated in table 5-1.

Filling.— Normally the servicing-trailer is filled from central supply tanks. These tanks have transfer hoses terminating in couplings that match the fill-drain line coupling on the trailer. Operation of the supply tank should be in accordance with the procedures in its operation manual.

Filling consists of the following procedures. Ensure that all required safety equipment is in use and all safety precautions have been taken. Place



LEGEND
GV—GAS VALVE
LV—LIQUID VALVE
LG—LIQUID LEVEL GAUGE
C—COUPLING
P—PRESSURE GAUGE
FI—FULL INDICATOR

CLOSE ALL VALVES BEFORE STARTING ANY OPERATIONS

FILL MAIN TANK
1. CONNECT C1 TO SUPPLY TANK
2. OPEN GV6 & LVI & OBSERVE LGI
3. WHEN TANK IS FULL CLOSE LV1 & DISCONNECT C1

FILL TRANSFER TANK
1. OPEN LV2 & GV3 & OBSERVE LG2
2. WHEN TANK IS FULL CLOSE LV2 & GV3

EMPTY TRANSFER TANK
1. OPEN GV5 & LV2 & OBSERVE LG2
2. WHEN TANK IS EMPTY CLOSE LV2 & GV5

FILL CONVERTER
1. FILL TRANSFER TANK
2. OPEN GV5 & OBSERVE P2 PRESSURIZE 80-100 PSIG
3. CONNECT C3 & C2 TO CONVERTER
4. OPEN GV4 & OBSERVE F1
5. WHEN F1 INDICATES LIQUID DISCONNECT C2
6. CLOSE GV4 & DISCONNECT C3
7. CLOSE GV5

Figure 5-9.—Operating instructions for TMU-70/M.

Table 5-1.—Periodic Inspection

Item	Inspection	Frequency
Exterior	Inspect for obvious physical damage, missing parts, illegible decals or plates, and missing or insecure attaching parts.	Daily while in use.
Piping and valves	Inspect for dents, nicks, or scratches; security of brazed or threaded connections; ease of valve movement and adequate seating and security of packings.	Daily while in use.
Gauges	Inspect for cracked dial face and security of installation.	Daily while in use.
Cabinet	Inspect for smooth hinge and guide operation and correct functioning of latches and legibility of decals and plates.	Daily while in use.
Tires	Inspect for correct inflation, tread wear, sidewall cracks or abrasions, and proper positioning of valve stems.	Daily while in use.
Wheel assemblies	Inspect for warps or dents in rims and freedom of rotation.	Daily while in use.
Retractable caster	Inspect for proper operation and undue wear or damage.	Daily while in use.
Controls	Inspect for loose, missing, or cracked handles; obvious physical damage.	Daily while in use.
Brake and cross shaft assemblies	Inspect for physical damage, missing parts, and ease of operation.	Daily while in use.
Converter fill and vent line hoses	Inspect for frayed wire in braid and worn or damaged fill and vent couplings.	Daily while in use.
Exterior cleanliness	Inspect visually for such contaminants as oil, grease, metal chips or scale.	Daily while in use.
	Inspect with ultraviolet light for presence of hydrocarbons.	Weekly.
Operation	Perform operational checkout.	Monthly or on receipt of new or repaired equipment.

the trailer on a level surface or ensure that the tank has a level attitude. Close all control valves on the storage tank. Pressurize the LOX supply tank to the required pressure for transfer to the TMU 70/M. Remove the dust cover from the supply tank transfer line and purge hose. After purging, connect the fill-drain line coupling (1) (fig. 5-8) to the transfer hose. Open the TMU 70/M's storage tank vent line shutoff valve (5) and fill-drain line shutoff valve (3).

CAUTION

Pressure should not be allowed to rise above 55 psi in the storage tank. Monitor the storage tank pressure gauge (7) closely during cooldown.

Open the service valve on the supply tank slowly, and allow only a partial flow of LOX through the transfer hose and into the trailer. Considerable vaporization will take place until the transfer hose, fill-drain line, and storage tank on the trailer have cooled down. When these have sufficiently cooled and are able to handle a full flow of LOX, open the service valve on the supply tank completely.

During filling, LOX flow is through the fill-drain line filter (2) and shutoff valve (3) to the storage tank. The relief valve (4) is provided to prevent excessive pressure if the fill-drain line shutoff valve and the service valve on the supply tank are closed with cold gas or liquid trapped within the supply line.

The relief valve (4) is connected to the vent line for safe discharge overboard. The vent line shutoff valve (5) is opened during filling and normal storage where safe overboard discharge is provide. Storage tank conditions are monitored and indicated by the liquid level gauge (6) and pressure gauge (7).

The inner shell relief valve (8) and rupture disc (9) are provided in case of excessive pressure in the storage tank. Monitor the storage tank liquid level gauge (6) during filling. When it indicates 50 gallons or LOX starts to flow out the vent manifold, close the service valve on the supply tank. Close the fill-drain line shutoff valve (3) to relieve internal pressure.

CAUTION

Use extreme caution when disconnecting the transfer hose. Even though the hose has been drained and the pressure relieved, some LOX will still remain. Do not direct the hose toward personnel or other equipment.

Disconnect the supply tank transfer hose, immediately drain the LOX that remains, and replace the coupling cap loosely. Tighten the cap after ensuring that all LOX has vaporized and bled off. Close all control valves on the service trailer except the storage tank vent valve (5).

NOTE: Observe the time required to fill the TMU-70/M. Filling will vary with each supply tank and supply line system. Under normal conditions and 30 psi transfer pressure, the storage tank should be filled within a period of 5 to 10 minutes. Abnormal deviation from the average filling time should be cause for investigation.

Transfer.— The transfer of LOX from the storage tank of the trailer to an aircraft converter can be done in the following manner.

Ensure that all safety equipment is in use. Close all control valves (3, 5, 10, 11,20, and 21, as shown in figure 5-8). Observe storage tank liquid level gauge (6) and pressure gauge (7) to ensure sufficient LOX supply and safe operating pressure. Open the transfer tank fill valve (10) and vent valve (11) to allow the transfer tank to fill.

When the transfer tank is full, as indicated by the liquid level gauge (13), close valves (10) and (1 1). Connect the converter vent line connector (16) to the converter vent fitting. Connect the AF filler valve (17) to the converter fill fitting, using a two-step procedure. First, position the valve against the purge fitting and turn the housing clockwise, locking the valve in place. Second, push the knurled knob forward and rotate clockwise, locking the valve in the open position. Open the transfer tank pressure buildup valve (21) momentarily and observe tank pressure gauge (12)

When pressure rises to approximately 90 psig, close valve (21). If necessary, maintain desired pressure by regulating pressure buildup valve (21) during converter servicing. Open the converter vent line shutoff valve (20) and observe the converter full indicator gauge (19). The gauge will indicate GAS as the converter is filling, and when full, it will indicate LIQUID.

As soon as it indicates LIQUID, disconnect the AF filler valve (17), close the transfer tank pressure valve (21), close the converter vent valve (20), and then disconnect the converter vent line connector (16).

If no other converters are to be serviced, empty the transfer tank, open fill line shutoff valve (10), and then the pressure buildup valve (21), if necessary, and observe the liquid level gauge (13). When the transfer tank is empty, close the pressure buildup valve (21) and then the fill line shutoff valve (10). Close all valves except the storage tank vent valve (5).

The flow of LOX from the storage tank to the aircraft converter is done as follows and can be traced using figure 5-8. The flow of LOX from the storage tank to the transfer tank is by gravity. It first passes through the transfer fill line shutoff valve (10) to the transfer tank. During this process, the gaseous oxygen produced by cooldown of the tank is vented back to the storage tank through the vent line shutoff valve (11). Conditions of the transfer tank are monitored and indicated by pressure gauge (12) and liquid level gauge (13).

When the transfer tank is filled to the desired level, as indicated by the liquid level gauge, valves (10) and (11) are closed. The converter lines are connected to the vent line connector (16) and filler valve (17). The filler valve is opened to allow the pressure in the converter and transfer tank to equalize. The transfer tank pressure buildup coil (PBU) is used to increase the pressure in the transfer tank to approximately 90 psig. This pressure is regulated by the pressure buildup valve (21) as required to maintain as high a pressure as possible during the servicing operation.

WARNING

The rate of pressure buildup depends on the liquid level in the transfer tank. On a full tank, the pressure will build extremely fast because of the small amount of vapor space to be filled. Use extreme caution in building the pressure, and never allow the pressure to exceed 90 psig. If observation of the rate of pressure buildup indicates it will exceed 90 psig, open transfer tank vent valve (11) to relieve the excessive pressure into the storage tank. This will avoid the opening of the relief valve (14) and the resultant undesirable discharge of gaseous oxygen from the vent line.

LOX is now able to flow from the transfer tank into the converter. When the converter full indicator gauge (19) indicates full, the overflow is returned to the storage tank by passing through the converter vent line shutoff valve (20). The filler valve (17) is then removed, the transfer tank pressure buildup valve (21) is closed, vent valve (20) is closed, and then vent line connector (16) is disconnected.

The preceding process is repeated until the storage tank is either empty or the maximum operating pressure, as indicated on storage tank pressure gauge (7), has been replaced.

MAINTENANCE.— Information and instructions for maintenance of the TMU-70/M storage tank are found in NAVAIR 19-25D-26. The Maintenance section is organized to provide information and instructions for the three levels of maintenance responsibility: organizational, intermediate, and depot. The capability of the using or supporting activity will be the limiting factor as to the level of maintenance that can be performed on the equipment. If maintenance of the equipment is beyond the assigned maintenance responsibility of the using or supporting activity, the next higher level of maintenance will perform the maintenance.

AMEs are only responsible for the organizational maintenance of LOX trailers, which include those functions normally performed in support of daily operations. Normal operational maintenance functions include inspection and preventive maintenance. Table 5-1 will assist you in understanding these functions.

System Servicing

Aircraft systems and LOX converters should be serviced in accordance with the appropriate maintenance instructions manual (MIM).

Only LOX conforming to MIL-0-2710, type II, may be used in aircraft LOX systems. The fire-fighting agents listed below are prohibited from use in conjunction with LOX-enriched fires.

1. Soda-acid extinguishers
2. Mechanical (liquid) foam
3. Methyl bromide
4. Carbon tetrachloride

CONTAMINATION CONTROL

Learning Objective: Recognize contamination control procedures for oxygen equipment to include detection, purging, and purging equipment.

The importance of using uncontaminated LOX in aircraft systems cannot be overstressed. Because of this, the Navy has established- the Aviators Breathing Oxygen (ABO) Quality Evaluation Program (A6-332AO-GYD-000). For additional information on contamination control, oxygen sampling, and oxygen system purging, refer to that program.

DETECTION

LOX contamination is detected by means of an odor test, sampling, and analysis. Only the odor test will be discussed in this manual because all other tests and analysis must be performed in a laboratory.

An odor test will be performed on LOX trailers after the first filling of the day, or each 6 days when the trailer is not in service. Aircraft LOX systems require an odor test to be performed as soon as possible after an aircraft accident/ incident or a report of in-flight odors by pilots or aircrew. The sample taken after an accident/ incident must be sent to a test site for analysis with details of the incident, including history of the supply source of the LOX.

Odor Test

The odor test is performed by pouring 200 milliliters (6.8 oz) of the sample into a clean 400 milliliter (13.8 oz) beaker or similar container after covering the bottom of the beaker with clean, dry filter paper or other absorbent paper. A watch glass cover or some other means of partially covering the top of the beaker will be provided as the 200 milliliters evaporates to dryness. This will prevent atmospheric constituents from being absorbed by the exposed liquid. The liquid is permitted to evaporate to dryness and warm up to approximately room temperature in an area free from air currents or extraneous odors. When the liquid has completely evaporated, the watch glass is removed, and the beaker contents smelled at frequent intervals until the accumulated frost on the outside of the beaker has completely melted. Odors will be most prevalent when the beaker has warmed to nearly room temperature.

If odors are present, the LOX container or system will be purged in accordance with existing directives.

Sampling

Sampling and analysis of LOX is required at any time contamination is suspected. Contamination of oxygen used in aircraft can cause many problems, from fire hazards to death of the crew member using the oxygen system. The most dangerous contaminate is hydrocarbons. The presence of hydrocarbons in LOX constitutes a potential fire and explosive hazard as well as causing psychological and physiological dangers to aircrews. Physiologically, the effects may be uneasiness, apprehension, or possible panic resulting from detection of odor. Psychologically, the effects may be nausea, illness, intoxication, or possibly asphyxia. Acetylene is the most hazardous hydrocarbon contaminate because it is highly insoluble in LOX, changing into a solid at extremely low concentrations. Once in its solid form, it can be readily triggered into ignition, and since it is chemically unstable, it can decompose under certain conditions and become its own source of ignition. The presence of acetylene in LOX has caused several major LOX generating plant explosions.

Inert solids are small contaminates that do not react with oxygen to create a fire or explosion, such as rust, dust, and fibers. They may cause mechanical malfunctions or failures by plugging filters, lines, or valves. Other contaminates commonly found in oxygen are water vapor, carbon dioxide, nitrous oxide, and halogenated compounds.

SAMPLING REQUIREMENTS.— Activities that produce LOX from on-base LOX plants must sample generating units for odor and purity after each addition, or if on continuous operation, once each 24 hours. The tank functioning as a receiver must have a sample taken every 90 days or when contamination is suspected and forwarded to a designated test site for analysis.

Base storage tanks are tested for odor each week, and a sample of the contents sent to a designated test site for analysis in accordance with table 5-2.

LOX trailers must be sampled when contamination is suspected and LOX converters must be sampled after any acciclent/incident. Samples must be forwarded to a designated test site for analysis.

Table 5-2.—Liquid Oxygen Storage Tank Sampling Schedule

Boil-Off Rate	Sampling Schedule
1%	Every 30 days
1½%	Every 20 days
2%	Every 13 days

SAMPLE TAKING.— In order to exercise rigid control over the quality of LOX manufactured by the Navy or civilian contractors and to test for suspected contamination, a sample must be taken from the LOX container.

Figure 5-10 illustrates the equipment and setup using the G-276 LOX sampler. Samplers are prepared at depot maintenance activities and shipped to the using activities, as required. Depot preparation includes the separation of valve, adapter, and cylinder; baking and evacuating the cylinder for 1 hour, and flushing once with gaseous oxygen; and finally, while still in the oven and still evacuated, the cylinder is filled to 20 psi with gaseous oxygen. The valve is then closed and the cap installed, and then it is shipped to the using activity.

There are several precautions that should be observed while you are sampling. Observing these precautions will help to ensure a representative sample. Do not sample from a trailer hose. Use only a short connection between the tank and sampler. A few feet of copper tubing, three-eights

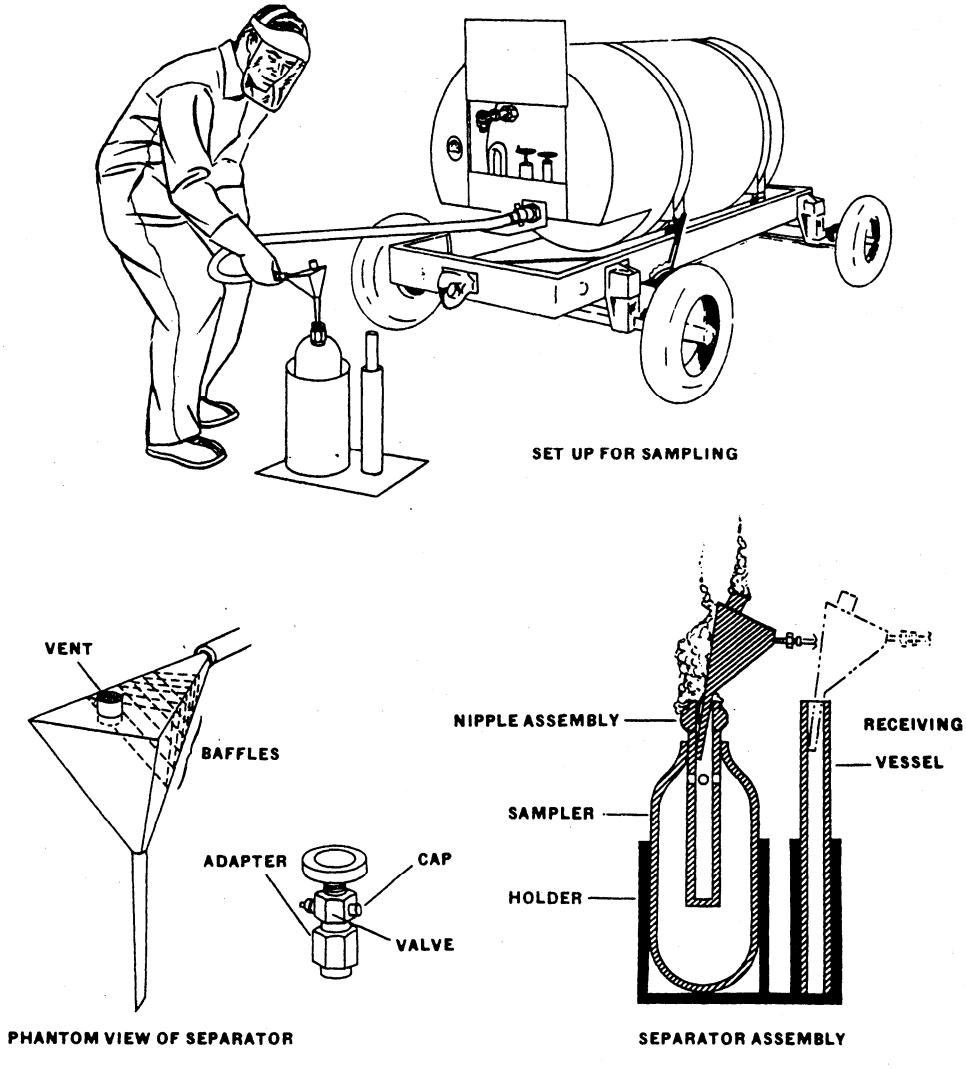


Figure 5-10.—Sampling.

inch in diameter, attached directly to the tank drain outlet, or trailer fill-drain outlet, is recommended by current directives. All flare fittings must be perfect—without dents, scratches, or toolmarks. Do not use any antiseize compound on threads or any cleaning compounds on sampler parts. Contamination will result. A sampler received without residual pressure probably leaks. Such samplers should be rejected and returned.

Just before sampling, remove the cap from the sampler valve; open the valve to release shipping gas pressure, then reclose. Next, remove the valve by disconnecting the adapter from the nipple, and place the cylinder upright in a holder.

Attach the separator and line assembly to the tank drain or fill-drain outlet. Using a trailer pressure of 10 to 20 psi, let the LOX flow into an open container, such as the receiving vessel shown in figure 5-10, for at least 30 seconds to purge the line. Adjust the pressure to obtain a quiet, uniform, full flow from the separator outlet tube.

Wipe the frost from the separator outlet tube, and immediately insert the outlet into the sampler tube and fill it. The filling will take approximately 1 minute. When liquid splashes in droplets over the top, the tube assembly is full. The sampling tube holds about 180 milliliters (6. 12 oz) of LOX, which produces a maximum pressure of 300 psi when vaporized in the closed sampler.

NOTE: During the filling operation, the operator should wear a face shield, hat, gloves, and other protective equipment as excessive pressure will violently throw LOX from the tube assembly.

As soon as the sampler tube is filled, remove the separator from the sampler assembly and install the adapter to the cylinder. Close it tightly with end wrenches, making sure that the valve is fully closed. Turn sampler upside down for a few minutes to allow liquid to flow from the sampler tube into the cylinder. Immerse the valve of the cylinder in water to check for leaks.

PURGING

Purging and other maintenance of LOX trailers is performed by the AS rating.

Purging is the cleansing of impurities from oxygen systems and containers. There are two ways to purge oxygen containers, LOX wash and gas purging.

The LOX wash method is used on large containers, such as storage tanks and LOX trailers, to lower the contamination to acceptable levels by replacing the contaminated LOX with LOX known to be uncontaminated.

To do this, drain the container using the buildup coil. Do NOT open the vent during this operation. Partially fill the container with uncontaminated LOX and allow the container to stabilize. Build up pressure to 30 to 40 psi and then vent the pressure to 0 psi. Repeat this operation for a total of three cycles. Take a sample and forward it to a designated site for analysis. If the sample is acceptable, the container may be put into service. If the sample is not acceptable, the container must be gas purged using hot water pumped nitrogen.

If allowed to run dry or if odor is detected in the system, aircraft LOX converters must be gas purged before being put into service. Gas purging of aircraft LOX systems must be done if any maintenance is performed on the system that opens it to the atmosphere.

To gas purge a LOX converter, first drain the converter of LOX. If possible, allow the converter to warm to ambient temperature. This saves vast amounts of nitrogen. Attach a purging device to

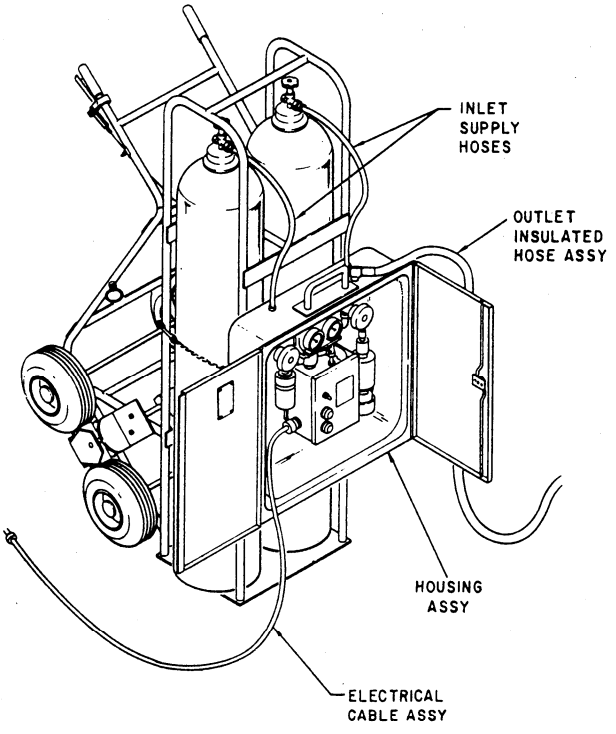


Figure 5-11.—Purging unit ready for use.

the converter and pass hot nitrogen 250°F (122°C) through the converter at 50 psi for at least 2 hours. The gas exiting the converter should exceed 100°F (38°C), or be in accordance with purging equipment instructions.

Next, service the converter and install it in the aircraft. Use an oxygen mask to smell for odors. If odors persist, drain and purge the converter again. Aircraft systems are purged in the same manner as a LOX converter. If an adapter is not supplied with the purging unit, use a supply fitting from a LOX converter.

Different types of purging equipment is used to purge oxygen containers and systems. Only one type unit, the Aircraft Liquid Oxygen System Gas Purging Set, manufactured by Avel Corporation, will be discussed here.

Description

This unit is designed to use water pumped gaseous nitrogen or gaseous oxygen to perform the purging process.

NOTE: Gaseous oxygen is to be used only if gaseous nitrogen is not available. All oxygen safety precautions must be strictly adhered to.

The unit consists of a hand truck and housing assembly, which contain the necessary controls and valves (fig. 5-11). Located within the housing assembly is an electrical enclosure containing a heater block assembly, switches, indicator lamps, and circuit breaker. When not in use, the supply and delivery lines, fittings and filler valve, electrical adapter (for conversion to 400 Hz power), and the electrical power connecting cord are stowed within the housing assembly. The housing assembly may be removed from the hand truck for use as a bench-mounted installation in the oxygen/converter repair shop.

Principles of Operation

As illustrated in figure 5-12, gas flows from the gas cylinders to the hand shutoff valves (HDV-1 and HDV-2), and then to the high--pressure relief valve (RV-1). This valve relieves

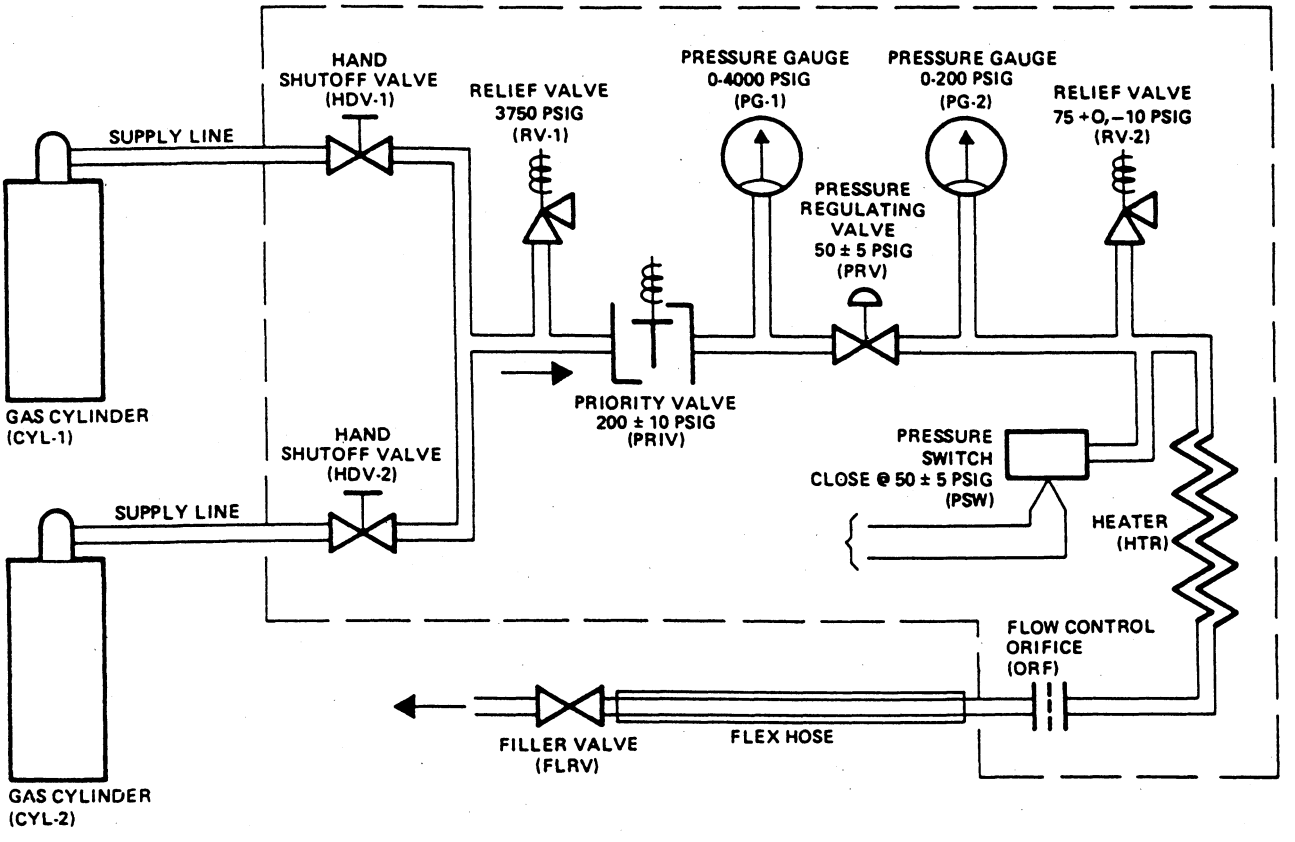


Figure 5-12.—Purging unit functional diagram.

pressures in excess of 3,750 psi. The gas then flows through the priority valve (PRIV). This valve is set to stop the flow of gas from the supply cylinders when cylinder pressure falls below 200 ± 10 psi. From the priority valve, gas flows to the pressure regulating valve (PRV). Pressure indicated on the high-pressure gauge (PG-1) is reduced to 50±5 psi by the pressure regulating valve. The reduced pressure is shown on the low-pressure gauge (PG-2). Gas then flows to the relief valve (RV-2), which is preset to 75+ 0, – 10 psi. From the relief valve, gas passes through the heater assembly (HIR), where the gas is heated to 285°F. The heated gas flow is then directed through the flow control orifice (ORF), which maintains the flow of gas at 0.20±0.017 pounds per minute at the regulated pressure of 50 ± 5 psi. The gas that exists in the filler valve (FLRV) will be at a temperature of 225±25°F.

Electrical power for the heating element in the heater (HTR) is controlled by the pressure switch (PSW) and two temperature switches. When gas pressure of 50±5 psi is reached, the pressure switch energizes the temperature control circuit and allows the heater assembly to warm. The temperature switch breaks contact within the circuit when the heater assembly temperature exceeds 285°F, and re-establishes contact when the heater assembly cools to 270°F, thus maintaining a temperature of 250°F to 260°F at the heater assembly discharge.

The high temperature switch functions as a safety switch. This switch is set to break the heater circuit when heater assembly temperature exceeds 300°F, and re-establish the circuit when temperatures fall below 273°F. For operational use of the purging unit, seethe users manual supplied with the unit or the *Liquid Oxygen, System Gas Purging Set,* NAVAIR 19-25D-27.

GASEOUS OXYGEN SERVICING TRAILERS

Learning Objective: Identify components and operating procedures for gaseous oxygen servicing trailers.

There are several different models of gaseous oxygen servicing trailers currently in use by naval activities. They are all similar in operation; therefore, only one, the type NO-2, manufactured by Aeroil Products, Incorporated, is described here. The trailer is shown in figure 5-13.

Equipment provided on the trailer includes six manifold control valves with pressure gauges; an upper and lower manifold; two pressure regulators; a recharge valve; four shutoff valves; a drier assembly, six cylinders, and connecting flexible hoses; and a servicing hose fitted with a line servicing valve fitted with a high-pressure charging adapter. The function of each of these components is described in the following text.

COMPONENTS

Complete familiarity with the following trailer components is a basic prerequisite for safe operation.

MANIFOLD CONTROL VALVES. The six manifold control valves serve to shutoff the flow of oxygen from the cylinders to the system being charged. These valves are lever-type valves. The manifold control valves should not be used for long-time storage. Always use the handwheel type valves located on the cylinders.

UPPER MANIFOLD. The upper manifold provides connections/mounting for the six manifold control valves with pressure gauges (each connected to a supply cylinder), a recharge valve, and two upper/inlet shutoff valves that connect to the inlet side of the regulators.

PRESSURE REGULATORS. The pressure regulator controls the charging pressure when the trailer is being used to service aircraft oxygen systems. Only one pressure regulator is used during operation. The spare is provided to ensure uninterrupted operation should one fail.

RECHARGE VALVE. The recharge valve is provided as a means of recharging the trailer cylinders directly through the upper manifold without the necessity of removing the cylinders. When not in use, the valve adapter should be fitted with a dust cap.

SHUTOFF VALVES. There are four shutoff valves, one on the inlet side of each pressure regulator and one on the outlet side of each regulator. These shutoff valves control the flow of oxygen from the upper manifold to the lower manifold, via the regulator.

When the shutoff valves on the inlet and outlet sides of the regulator are open, the pressure regulator is ready for use. By turning the regulator control-handle clockwise, the pressure (as read on

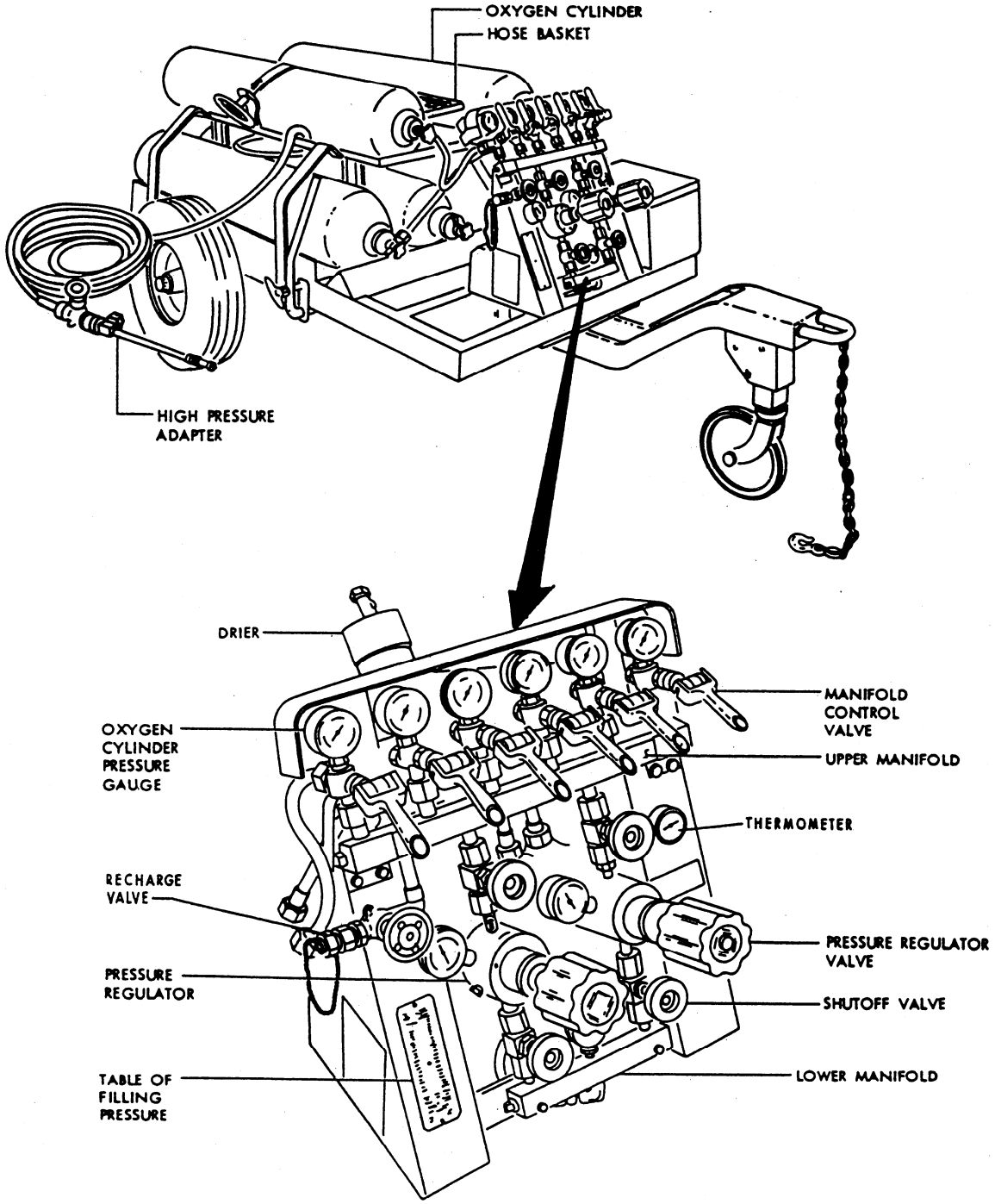


Figure 5-13.—Type NO-2 gaseous oxygen servicing trailer.

the gauge attached to the regulator) will increase. Turning the control handle counterclockwise decreases pressure.

LOWER MANIFOLD. The lower manifold provides connections/mountings for the two lower/outlet shutoff valves from the outlet side of the regulators, a delivery pressure gauge, and a flexible hose that connects the lower manifold to the drier assembly.

DRIER ASSEMBLY. The drier assembly is a reservoir containing a chemical drying agent through which oxygen must pass before going

through the servicing hose. This chemical drier is provided to remove any moisture in the oxygen supply. The oxygen flows into the bottom of the drier, passes up through the drying agent, and out through the servicing hose.

SERVICING HOSE AND LINE VALVE. The servicing hose is a high-pressure, nonkinking, metallic flexible hose. The line servicing valve is attached to the servicing hose and is used to control the flow of oxygen to the system being charged.

OPERATION

The six supply cylinders are connected by means of flexible hoses to their respective control valves (fig. 5-14). The six control valves are attached to the upper manifold. A pressure gauge is screwed into each control valve at a point below the seat. This allows each cylinder pressure to be easily read.

The oxygen flows from the upper manifold through either of two pressure regulators via two shutoff valves.

The oxygen is collected in the lower manifold where a gauge registers the pressure of the delivery side of the system. The lower manifold is connected by flexible hose to a drier, which filters and dries the oxygen. The servicing hose connects directly to the drier and has a line servicing valve on the terminal end. The line servicing valve is fitted with a standard oxygen cylinder connection.

Loading Cylinders

The servicing trailer is capable of having its cylinders recharged without removal. However, many operating activities replace the empty cylinders with full cylinders.

NOTE: NEVER completely expend the supply of oxygen from a cylinder. Always leave a residual pressure in excess of 50 psi.

REMOVAL OF EMPTY CYLINDERS.— When the trailer has been in use and cylinder pressure is low, the cylinders are removed as described below.

1. Close all lever valves on the manifold prior to removing any cylinders.
2. Close the cylinder shutoff valves.
3. Disconnect the flexible hose that connects the cylinder to the manifold.
4. Loosen the clamping arrangement that holds the cylinders to the trailer.
5. Install the cylinder safety caps.
6. Remove the empty cylinders.

CAUTION

Do not attempt to remove empty cylinders while charging.

INSTALLATION OF FULL CYLINDERS.— The trailer should be loaded with cylinders while fastened to a towing vehicle. If a towing vehicle is not available, the rear stand should be let down and hand brakes applied so the weight of the cylinders will not cause the trailer to tilt backwards. The retractable swivel wheel should be down if the trailer is not hooked to a towing vehicle. (When the trailer is hooked to the towing vehicle, the swivel wheel should be retracted.) Cylinders should be loaded from the rear and should be handled with safety caps in place. Standing cylinders should be brought to within 4 feet of the rear end of the trailer. If the cylinders are lying down, the safety cap end of the cylinder should be just below the rear of the trailer. The safety cap end of the cylinder should be lifted or lowered and placed in the appropriate channel. The bottom of the cylinder should be raised and the cylinder worked into place.

Ensure that the cylinder is in its forward-most position and firmly seated against the forward cylinder stop. Remove the cylinder safety cap. Position the cylinder so that the cylinder valve outlet may be easily connected to the flexible hose without causing undue strain on the hose. Prior to connecting the hose to the cylinder, open the cylinder. valve slightly to blow any foreign matter from the outlet of the valve; then close the valve. Connect the flexible hose nut to the power cylinder valve. As soon as the cylinders are in place and the hoses connected, the clamping arrangement should be tightened.

The bottom four cylinders are clamped in pairs by a wheel, and the top cylinders are tightened by a single strap for each one.

After tightening the coupling nuts on the hoses, the hoses should be free of twisting strain. This strain can be prevented by gripping the hose with one hand and twisting slightly in a clockwise direction while tightening the coupling nut. When the nut becomes tight, the hose will twist (counterclockwise) slightly as it seats, and will stop approximately at its neutral position.

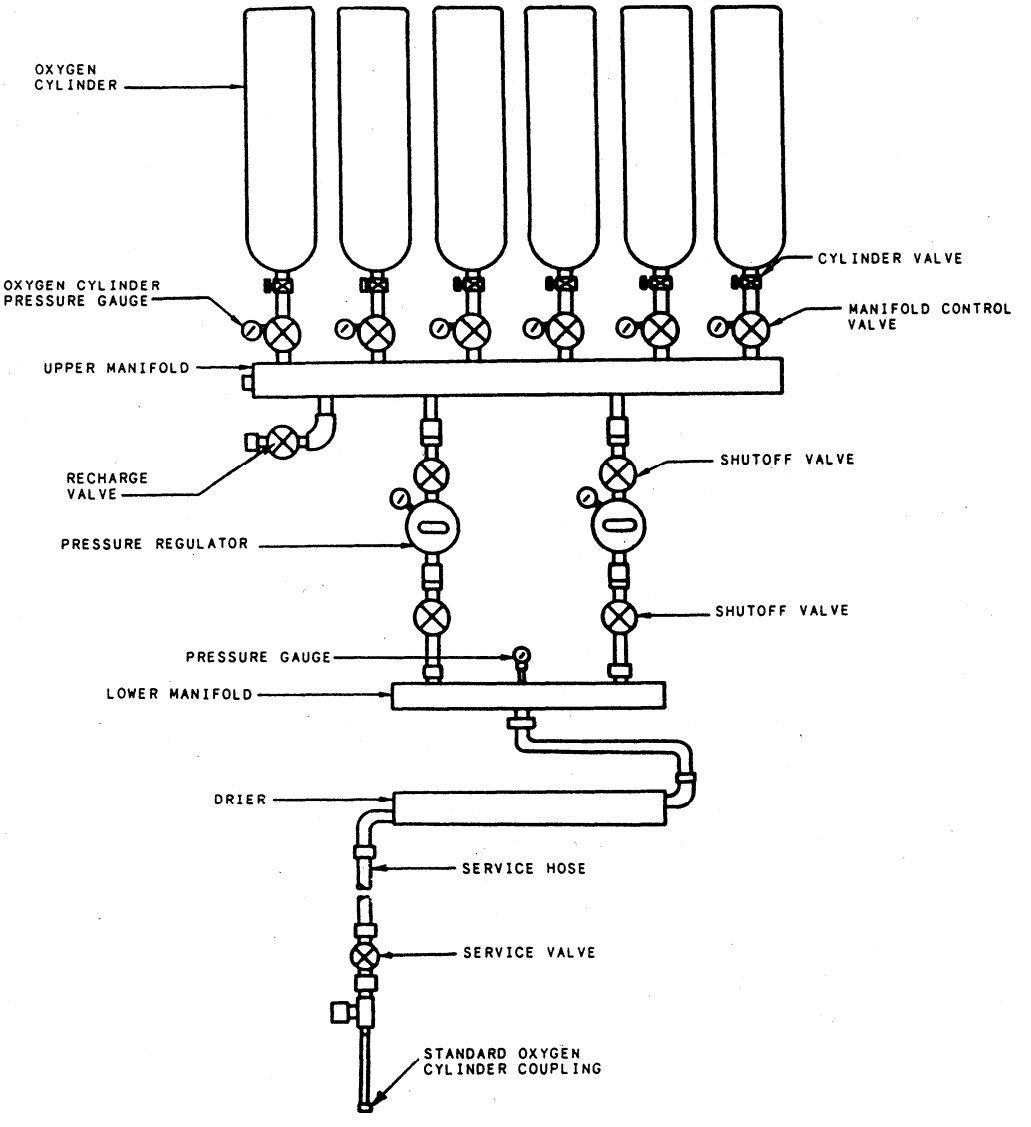


Figure 5-13.—Type NO-2 gaseous oxygen servicing trailer (schematic).

CAUTION

To eliminate the danger of an explosion, do noninterchange parts between oxygen servicing equipment and air/nitrogen equipment.

After replacing the empty cylinders, the cylinder valves on the full cylinders should not be opened until the trailer is positioned for servicing an aircraft.

Replacement of Drying Agent

The chemical drier should reinspected after every 12 cylinders are used, and the chemical agent should be replaced at the first sign of change in the indicator. The blue-colored indicating agent is applied on top of the white drying agent. When moisture is present, the indicating agent will change color from blue to pink. The indicating agent can be easily inspected by removing the servicing hose and unscrewing the top cap of the drier container.

CAUTION

Relieve all pressure prior to inspection/ replacement of the chemical agent.

The drying agent is removed by removing the hose connecting the lower cap and the lower manifold and unscrewing the drier lower cap. All traces of the contaminated agent should be removed and the lower cap replaced, and the lower manifold hose connected. The drying agent should be quickly placed in the drier so that it does not pick up moisture from the air. Care should be given to the replacement of the indicating agent. The top cap should be screwed in place immediately after observing the condition of the indicator so that the moisture or humid air does not cause the indicator to change color.

The caps on the drier should be screwed down until they bottom. The caps should be removed and replaced by hand only. It is not necessary to tighten the caps extremely tight. The caps are sealed with O-ring packings, which usually give good service. If leakage occurs, the O-ring should be replaced. Refer to the applicable Operation and Service Instruction Manual (which includes the Illustrated Parts Breakdown) for the part number of the O-ring.

NOTE: All maintenance on the oxygen servicing trailer should be performed in accordance with the instructions contained in the applicable Operation and Service Instructions Manual or set of Maintenance Requirements Cards.

Daily/Preoperational Inspections

Maintenance requirements for the gaseous oxygen servicing trailer are provided on daily, preoperational, or periodic maintenance re-requirement cards. These cards provide the minimum requirements necessary to maintain the equipment and ensure that no item is overlooked. They do not contain instructions for repair, adjustment, or means of rectifying defective conditions. The cards are arranged in a work area sequence similar to aircraft maintenance requirements cards so that the inspections can be held in an efficient manner.

The daily requirements should be accomplished prior to the first use of the equipment for that day. It may be necessary to repeat some of the requirements prior to each use of the equipment.

Gaseous Oxygen System Servicing

The danger involved in the transfer of gaseous oxygen as well as its importance to the pilot requires that it be handled with care. The following general safety precautions should be followed for safe operation of the oxygen servicing trailer:

1. Only qualified operators should operate the trailer for recharging aircraft oxygen systems. Complete familiarity with the trailer is a basic prerequisite to safe operating techniques.
2. The aircraft electrical system must be turned off, and no other servicing should be conducted on the aircraft while servicing the oxygen system.
3. Never permit oil, grease, or other readily combustible materials to come in contact with oxygen cylinders, valves, regulators, gauges, or fittings.
4. The servicing hose and aircraft connection fittings must be thoroughly inspected prior to servicing. Any trace of oil, grease, or foreign material must be carefully removed.
5. The servicing hose should always be bled prior to connecting with the aircraft oxygen system.
6. Open all valves slowly.
7. Always know the pressure existing in the aircraft system to be filled and the pressure in all cylinders to be used in the refueling process before starting the recharging operation.
8. Ensure that the line valve on the discharge end of the servicing hose is closed at all times when not actually servicing aircraft.
9. Never have more than one cylinder control valve open during operation.
10. The servicing hose must never be tightly stretched to reach a connection. Position the trailer so that the hose is not under tension.
11. When disconnecting the transfer hose from an aircraft fitting, loosen the connection slowly to prevent rapid bleeding of the trapped oxygen.
12. A malfunctioning pressure regulator should be disconnected from the line by closing its associated shutoff valves. The trailer can then be operated with the remaining pressure regulator.
13. When moving the trailer from place to place, cylinder valves should be closed.

Before servicing an aircraft gaseous oxygen system, you should take care to ensure that the six manifold control valves on the trailer control panel are closed. If these valves are partially opened, the cylinder pressure will equalize from one to the other.

The following are general procedures for servicing a high-pressure oxygen system.

NOTE: Since aircraft oxygen systems vary in design, always check the applicable MIM or maintenance requirements card prior to servicing an aircraft oxygen system.

1. Prior to servicing (recharging) an aircraft gaseous oxygen system, ensure that the following conditions exist on the aircraft and the oxygen servicing trailer.
   a. The trailer and aircraft should be properly grounded.
   b. The line valve on the oxygen servicing hose should be closed.
   c. All six trailer manifold control valves should be closed.
   d. Both pressure regulators and their associated shutoff valves should be closed.
   e. All six individual cylinder valves should be opened and the individual cylinder pressures noted.

2. Open the cylinder valve and then the manifold control valve on the cylinder with the lowest pressure above the aircraft system pressure.

3. Open the two shutoff valves on each side of the pressure regulator valve that is to be used. (The oxygen servicing trailer is equipped with two pressure regulators so that in the event of the failure of one, the other maybe used.)

4. Slowly open the pressure regulator valve (by turning the control knob clockwise) and allow the pressure to buildup to the trailer cylinder pressure. The set pressure of the regulator may be noted on the regulator gauge.

NOTE: A temperature connection charge is given in the applicable MIM or on the side of the servicing trailer. This chart is used to determine the pressure to which the aircraft cylinders should be filled. This pressure depends on the ambient temperature, as maybe noted on the thermometer on the trailer manifold stand.

5. Slowly open the service valve on the servicing hose, and bleed the hose to ensure that all loose foreign matter that might be within the hose is expelled.

6. Close the service valve on the hose, and attach a high-pressure adapter to the coupling nut on the servicing valve.

7. Open the access panel to the aircraft oxygen filler valve. Check the filler valve and the area around the filler valve for any trace of oil, grease, or any other foreign material. Clean the area if necessary. Unscrew the dust cap from the aircraft filler valve.

8. Connect the service hose high-pressure adapter to the aircraft filler valve.

9. Slowly open the service valve on the hose. When there is no longer a flow of gas (lower manifold gauge is within 15 pounds of the supply cylinder gauge), close the cylinder valve and the manifold control valve, and repeat the process with the cylinder with the next higher pressure. Work cylinders in increasing order of their pressure until the aircraft system pressure has reached the desired reading.

NOTE: Oxygen under high pressure will increase in temperature during the servicing procedure. To obtain the desired pressure in the aircraft system, cylinders should be filled slightly above 1,800 psi (+50 to +200 psi), depending upon the ambient temperature.

10. After fully charging the aircraft system, close the service hose valve, shutoff valves, pressure regulator, and associated shutoff valves, manifold control valves, and cylinder control valve, in that order.

11. Disconnect the servicing hose from the aircraft filler valve, and relieve the hose pressure by opening the service valve on the hose.

12. Close the service valve and stow the hose in the trailer hose basket.

13. Replace the aircraft filler valve dust cap and the access plate.